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Abstract

This paper reports on an analysis of productivity growth and input trends in six energy intensive sectors of the Indian economy, using growth accounting and econometric methods. The econometric work estimates rates and factor price biases of technological change using a translog production model with an explicit relationship defined for technological change. Estimates of own-price responses indicate that raising energy prices would be an effective carbon abatement policy for India. At the same time, our results suggest that, as with previous findings on the US economy, such policies in India could have negative long run effects on productivity in these sectors. Inter-input substitution possibilities are relatively weak, so that such policies might have negative short and medium term effects on sectoral growth. Our study provides information relevant for the analysis of costs and benefits of carbon abatement policies applied to India and thus contributes to the emerging body of modeling and analysis of global climate policy.

INTRODUCTION

In December 1997, in Kyoto, the Annex I (industrialized) countries assumed differential commitments to reduce their greenhouse gas (GHG) emissions to an average of 5.2% below their 1990 emissions rates by approximately 2010 (UNFCCC, 1997). Earlier analyses of GHG emissions have shown, however, that it will not be possible to stabilize atmospheric CO_2 concentration levels if industrialized countries alone limit their emissions (Lashof and Tirpak, 1990).

While the developing countries' (i.e. non-OECD countries excluding the former Soviet Union, Central and Eastern Europe) share of world fossil fuel consumption is presently small, rapid population and economic growth will result in a substantial increase of this share in the first part of the 21st century. From 15% of world energy demand in 1971, the developing countries are expected to account for 40% of this demand by 2010 if present trends continue (IEA, 1994). Even with aggressive policies to promote energy efficiency, developing countries' energy demand is likely to grow 5-10 fold over the next 30-40 years, resulting in a 3-fold increase in world energy demand. Consistent with a rapid growth in energy use, carbon emissions from the developing world increased at an annual rate of 4.4% between 1990 and 1996 (Sathaye and Ravindranath, 1998). Growth rates for the larger developing economies were same or higher at 4.4% for China, 6.7% for India and 10.3% for South Korea.

The participation of developing countries is thus essential for attaining the goal of global carbon abatement. Many developing countries, however, are demonstrably concerned that aggressive carbon abatement efforts on their part may have adverse effects on their economic growth and efforts to improve living standards. Hence, there is a need for enhanced analysis of their long-run energy use, carbon emission and technological trends to determine how the joint goals of economic improvement and climate protection might best be achieved.

Numerous integrated assessment models (IAMs) have been developed to analyze the economic impacts of climate change (Weyant et al., 1996). Most such models show that GDP growth may be reduced if policies such as carbon taxes are implemented to reduce emissions.[1] At the same time, however, most IAMs have not incorporated regional or country-specific disaggregation. In addition, the IAM's canonical treatment of technological trends related to energy efficiency has been in terms of reduced form parameters (characteristically referred to as "autonomous energy efficiency improvement" parameters) that do not allow for refined analysis of the relations among energy use, economic growth, and policies. Consequently, an important frontier for IAM research is the simultaneous pursuit of developing country-specific analysis combined with more detailed investigation of technology, energy and productivity trends.

This paper reports on such a study for India, on long-run productivity and input trends in six energy-intensive sectors of the Indian economy: paper and paper products, cement, fertilizer, glass, iron and steel and aluminum. We have also studied aggregate manufacturing and the industry sector as a whole. We apply both growth accounting and econometric methods to these sectors. Our aim is to begin replicating for the Indian economy the extensive body of research on productivity, energy use, and related trends that has been previously conducted on the U.S. economy. We hope to inform policy analysts of the costs and benefits of carbon abatement policies applied to India, and thus contribute to the emerging body of modeling and analysis of global climate policy.

Previous work

Following the oil shocks of the 1970s a large body of econometric work on energy use emerged (see Roy, 1992, and Sarkar and Roy, 1995, for a survey). This work focused primarily on understanding short-run patterns, particularly those of inter-fuel and inter-input substitution. However, for purposes of carbon policy, long-run trends are equally or more important. In particular, long-run patterns of technological

[1] One more recent study regarding carbon taxes in India has been conducted for example by Fisher-Vanden et al. (1997). They investigate the effects of two policy instruments (carbon taxes and tradable permits) on the Indian economy and find that carbon taxes represent the higher cost method to stabilize Indian emissions than tradable permits. Depending on the allocation scheme of tradable permits India could benefit absolutely from participating in a global tradable permits market or could experience a slowdown in economic growth.

change affecting the use of inputs, including energy, may have major consequences for estimates of the costs and benefits of various carbon policies. This fact has been the focus of considerable attention (and controversy) among energy analysts, who have focused on the magnitude and interpretation of "autonomous" trends of declining energy intensity.

In recent decades, several methodologies have been developed and applied to examine changes in productivity and technological development. The standard growth accounting approach, pioneered by Solow (1957) and further developed by Denison (1974, 1979, 1985) and others, can be employed to study long run trends in energy use and its relationship to other economic variables. In addition, Christensen and Jorgenson (1971), Hogan and Jorgenson (1991), Hudson and Jorgenson (1974), and Jorgenson et al. (1981, 1987) have developed and applied methods that allow for an enhanced analysis of the relations between substitution effects induced by changes in relative factor prices, and pure 'productivity' trends, on a sector specific basis over long time periods. They have demonstrated that combining a finer level of analysis (in particular, sectoral disaggregation) with a form of "endogeneity" in the modeling of technological change can reveal patterns that are not readily detected by more traditional methods. These patterns can have substantial implications for conclusions regarding the long run costs and effects of price-based carbon abatement policies.

Berndt and Watkins (1981) studied productivity growth in the aggregate Canadian economy and in two Canadian manufacturing sectors for the period 1957-76, and examined technological change using both accounting and econometric methods. Jorgenson and Fraumeni (1981) and Jorgenson, Gollop, Fraumeni (1987) estimated both productivity growth and rates of technological change for 35 sectors of the U. S. economy during the post-war period (1948-79). Hogan and Jorgenson (1991) examined the relationships among productivity growth, biases in technological change, and long-range impacts of carbon-abatement policy in the U. S. economy. They found that these biases, although small, could result in substantial long-run "externality" impacts on productivity from policies that increased relative energy prices as a means of reducing carbon emissions.

A number of studies have estimated total factor productivity for the Indian economy using statistical indices within the standard growth accounting framework (for a detailed survey see Mongia and Sathaye, 1998, 1998a, Ahluwalia, 1985, 1991). There has also been a considerable amount of econometric work on inter-fuel and inter-input substitution for the Indian economy (for a survey see Ganguli and Roy 1995), but very little (Jha et al., 1993) on long-run trends in the relations between technological change and fuel or input substitution. A comprehensive survey of research on total factor productivity in East Asia reveals a focus on capital and labor inputs, rather than energy (Felipe, 1997).

METHODOLOGY

Our analysis is in two parts. First, we estimate sectoral and aggregate trends in multi-factor productivity growth or technical change for the selected industries using growth accounting methods. Second, we analyze patterns of productivity change using an econometric model that explicitly considers several factors affecting productivity.

Growth Accounting Framework

The approach here is in contrast to the traditional two input value-added growth accounting approach, in which only labor and capital are included. Instead, we assume that the rate of growth of sectoral output is the sum of the contributions of capital, labor, energy, material and rate of productivity growth. Assuming a production function relating output to four inputs with constant returns to scale and B as an index of the state of technology

$$Q = B\, f(X_k, X_l, X_e, X_m) \qquad (1)$$

and adopting a translog form

$$ln\,Q = ln\,B + \sum_i a_i\, ln\,X_i + \tfrac{1}{2}\sum_i \sum_j b_{ij}\, ln\,X_i\, ln\,X_j \qquad i,j = k,l,e,m \qquad (2)$$

the standard approach to measuring productivity would be to differentiate Q with respect to time:

$$\begin{aligned}\frac{d\,ln Q}{dt} &= \frac{\partial\, ln B}{\partial t} + \frac{\partial\, ln Q}{\partial\, ln X_k}\frac{\partial\, ln X_k}{\partial t} + \frac{\partial\, ln Q}{\partial\, ln X_l}\frac{\partial\, ln X_l}{\partial t} \\ &+ \frac{\partial\, ln Q}{\partial\, ln X_e}\frac{\partial\, ln X_e}{\partial t} + \frac{\partial\, ln Q}{\partial\, ln X_m}\frac{\partial\, ln X_m}{\partial t}\end{aligned} \qquad (3)$$

In terms of the translog formulation in (2), output elasticity terms in (3) would be

$$\frac{\partial\, ln Q}{\partial\, ln X_i} = a_i + \sum_j b_{ij}\, ln\, X_j \qquad i,j = k,l,e,m \qquad (4)$$

Under constant returns to scale and with competitive markets, however, we can write (4) as

$$\frac{\partial\, ln Q}{\partial\, ln X_i} = \frac{\partial Q}{\partial X_i}\frac{X_i}{Q} = \frac{P_i X_i}{PQ} = M_i \qquad i = k,l,e,m \qquad (5)$$

i.e. output elasticities are simply equal to input cost shares M_i.

Now substituting cost shares in (3) and taking the change in input quantities in a discrete time period we can write

$$\dot{Q} = \dot{B} + \sum_i \overline{M}_i \dot{X}_i \quad i = k,l,e,m \qquad (6)$$

The contribution of each of the input is the product of the average value share of the input and its growth rate. Since B is an index of the state of technology we find that multifactor productivity or the rate of technical change $\dot{B}$ is simply the growth in outputs minus growth in inputs weighted by shares. $\dot{B}$ represents the percentage of outward shift in the production function resulting from technical progress. From this accounting framework we can obtain the time series of the rate of technical change as a residual.

Econometric Framework

In the second stage we adopt the econometric framework to determine the pattern of technical change aimed at estimating rates and factor price biases of technological change. For this purpose, we apply the methodology developed and applied by Jorgenson et al. (1981), and Hogan and Jorgenson (1991). Models of individual sectors are based on production theory, with sectoral output a function of capital, labor, energy and materials inputs (the "KLEM" approach). It permits a considerably more detailed analysis of the relations among demand for relevant factor inputs, changes in relative prices, changes in output, and technological change.

More precisely, each sector is assumed first to admit representation by a constant returns-to-scale production function of the form

$$Q = f(X_k, X_l, X_e, X_m, t) \qquad (7)$$

where Q is sectoral output, and X_k, X_l, X_e and X_m are sectoral inputs of capital, labor, energy and materials, respectively. t is time, representing B of equation (1) which enters the production function here to represent the way in which feasible input combinations are affected by time dependent technological progress, i.e. by multifactor productivity. Although Indian industries have historically operated within a regulated environment determined by licensing policy, output and input price controls by government we adopt as a benchmark the assumptions of perfect competition and assume price taking and cost-minimizing behavior across all ownership patterns. As can be seen in Table 1 most of the ownership is in private hands. Table 2 further provides a brief overview regarding the liberalization of price and distribution controls applied across sectors and over time.

Thus, in equilibrium, constant returns to scale implies that in each sector the value of output is equal to the sum of the values of capital, labor, energy and materials inputs. We can then define sectoral price functions for each sector by expressing the sectoral output price as a function of the prices of capital, labor, energy, and materials inputs, and time. Homogeneity of degree one of the production function then implies the existence of a dual unit cost function giving output price as a function of input prices.

$$G = g\ (P_k, P_l, P_e, P_m, t) \qquad (8)$$

Moreover, expenditure shares for each of the inputs can be expressed in terms of derivatives of the cost function, and the rate of change of total factor productivity is equal to the negative of the trend in output prices.

$$M_i = \frac{\P\, lnG}{\P\, ln P_i} = \frac{p_i X_i}{\sum p_i X_i} \qquad i = k,l,e,m \qquad (9)$$

$$-v_t = -\frac{\P\, lnQ}{\partial t} = \frac{\P\, lnG}{\partial t} \qquad (10)$$

We adopt a translog functional form, so the dual unit cost function or output price can be written as

$$\begin{aligned} G^s = {} & ln a_0^s + \sum_i a_i^s\, ln\, p_i^s + a_t^s t + \tfrac{1}{2}\sum_i \sum_j b_{ij}^s\, ln\, p_i^s\, ln\, p_j^s + \sum_i b_{it}^s\, ln\, p_i^s\, t \\ & + \tfrac{1}{2} b_{tt}^s t^2 \end{aligned} \qquad (11)$$

for i,j = k,l,e,m and s = 1,2,..,8 (six energy intensive industrial sectors, aggregate manufacturing and total industry).

Linear homogeneity of the price function follows from the parametric restrictions:

$$\begin{aligned} & \sum_i a_i^s = 1, \\ & \sum_i b_{ij}^s = \sum_j b_{ij}^s = 0, \quad i \neq j \\ & \sum_i b_{it}^s = 0 \end{aligned} \qquad (12)$$

Symmetry of share elasticities and biases of productivity growth imply the further restrictions:

$$\begin{aligned} & b_{ij}^s = b_{ji}^s, \quad i \neq j \\ & b_{it}^s = b_{ti}^s \end{aligned} \qquad (13)$$

Value shares of capital, labor, energy and materials are derivatives of the cost function as shown in (9), so that an econometric model is obtained by adding stochastic component as:

$$M_i^s = a_i^s + \sum_j b_{ij}^s \ln p_j^s + b_{it}^s t + u_i^s \,, \quad \forall i \qquad (14)$$

Finally, the rate of technical change for each sector can be expressed as the negative of the rate of price growth of sectoral output with respect to time as defined in (10), holding input prices constant:

$$-v_t^s = a_t^s + \sum_i b_{it}^s \ln p_i^s + b_{tt}^s t + u_t^s \qquad (15)$$

In this model, rates of productivity growth and the value shares of inputs are endogenously determined. Since value shares sum to unity, the random disturbances in the four value share equations above are not independently distributed. However, from the cross equation restrictions, we observe that any three of the value share equations, along with the technological change equation, together yield estimates for all parameters. Since the value shares sum to unity, the sum of the disturbances across any three equations is zero at all observations. Hence, to avoid singularity of the covariance matrix any one of the four share equations can be dropped, i.e., three can be estimated and the fourth automatically determined. We drop disturbance from capital equation and iterative method may be applied to overcome the bias for the deleted equation. We follow the algorithm provided in the standard econometric package TSP 4.4 following the method described by Berndt, Hall, Hall and Hausman (1981).

From the parameter estimates of the above model we can derive AES (σ_{ij}) and price elasticities (E_{ij}) and average productivity elasticities (η_{ij}) using following relations:

$$\sigma_{ij} = \frac{b_{ij} + M_i M_j}{M_i M_j}, \quad i, j = k, l, e, m, \quad i \neq j \qquad (16)$$

$$\sigma_{ii} = \frac{b_{ii} + M_i^2 - M_i}{M_i^2}, \quad i, j = k, l, e, m, \quad i = j$$

$$E_{ij} = M_j \sigma_{ij} \qquad (17)$$

The share equations can be interpreted further. Using the unit cost function (11) and the derived demand equation (9) we can get the cost minimizing input-output coefficients (Berndt and Watkins, 1981). The cost minimizing input-output coefficients (X_i/Q) are simply the reciprocals of the average productivity measure defined as

$$ap_i = Q/X_i \qquad (18)$$

Thus, in the above model, average productivity depends on technology, input prices and multifactor productivity.

Using equation (18) the elasticity of average productivity (Berndt and Watkins, 1981) of the ith input with respect to a change in price of jth input can be defined as:

$$\eta_{ij} = \frac{\partial \ln ap_i}{\partial \ln p_j} = -\frac{\partial \ln X_i}{\partial \ln p_j} = -E_{ij} \qquad (19)$$

Following Berndt and Watkins (1981) the average productivity elasticity is simply the negative of the familiar price elasticity.

Since by definition own price elasticities need to have a negative sign the average productivity elasticities for all the inputs would be positive with own price change. Thus, an increase in price of an input would increase its productivity and that of complementary inputs but will reduce the productivity of substitutable inputs.

The parameters a_i can be interpreted as average value shares of capital, labor, energy and materials inputs for the corresponding sector, and a_t as the average of the negative of rates of (sectoral) technological change or "pure" productivity improvement. b_{it} has a two-fold interpretation. It represents the change in share of the ith input over time when relative factor prices are held constant that is, it is the impact of technology trends on input shares, or "factor price bias". Under the assumptions of the model, it displays also the impact on the trend in total factor productivity with changing input prices. b_{tt} can be interpreted as constant rates of change or acceleration of the negative of the rates of technical change. If the estimated value is positive, the rate of technical change is decreasing. And if negative, the rate is increasing.

In the case of energy share, a positive value of the parameter b_{it} would mean a greater pressure on expansion of output with rising energy prices, due to greater energy use. Alternatively, if energy price rises, the trend in total factor productivity will decline. As Hogan and Jorgenson (1991) demonstrated for the U.S. economy, such patterns can have an important impact on long-run projections of carbon abatement costs. If higher energy prices retard productivity growth, then future output (and aggregate consumption) may be reduced indirectly as a result of energy conservation attained through policies that increase energy prices.

The parameter b_{ij} is interpreted as constant share elasticity with respect to the price of inputs. Along with the Allen Elasticities of Substitution (AES) and price elasticities, these parameters can yield short and medium run policy implications. They describe the implications of patterns of substitution among the four inputs for the relative distribution of the value of output among the inputs. Positive share elasticities imply that value shares increase with price.

DATA

Relevant data were collected from various editions of the Indian Annual Survey of Industries and different volumes of the Index of Wholesale Prices in India (Government of India, 1973-1993; Mongia, 1998). In particular, we obtained data on value shares for the four input factors, for each of the industries, for the period 1973-93. These data, along with sectoral price indices for outputs and inputs, and translog indices for sectoral rates of technical change, were used to estimate the model's parameters.

It is conventional in the literature to represent the service price of capital as a function of depreciation and the long-term interest rate. For developing countries, however, it is arguable that the social rate of discount should instead be used (Shankar and Pachauri, 1983). In these countries, long-term interest rates typically do not reflect the cost of capital. In many cases interest rates are low, and severely distorted due to the effects of inflation. In such circumstances, the social discount rate - which also reflects the yield from the public sector at the margin, and is used by the government - can be used as a surrogate.

We have adopted 12% as the social rate of return, which is also the yield from marginal public sector investment in the Indian economy. We represent the flow price of capital as a linear function of the asset price (price index of investment goods as reflected in the machinery price index), the social discount rate and depreciation (Goldar, 1986). In a similar way, the flow of capital services, our capital input, is assumed to be proportional to the corresponding capital stock. For labor input, the number of persons employed and the wage calculated from emoluments per person employed have been used for model estimation. For energy and materials, aggregate price indices and expenditure figures have been used. For productivity trends, translog indices calculated from the growth accounting framework have been used.

RESULTS

Growth Accounting

The decomposition analysis in Table 3 compares the annual growth rate of output of each industry with the input and productivity growth for the period 1973-1993. Over the twenty year period aggregate manufacturing as well as total industry have grown at an average annual rate of over 7%. Average annual rates of growth of the selected energy intensive sectors vary from 5% to 10%. The fertilizer sector experienced higher average annual growth slightly over 10%, followed by cement with 8.69%, iron and steel 7.58%, glass 6.38%, paper 5.25% and aluminum 5.10%.

However, the performance of each sector was not steady over this whole period of twenty years. A common observation is that the growth of the sum of the inputs dominates over productivity growth of the selected industries in accounting for sectoral output growth. For aggregate manufacturing, for example, total input growth accounts for 95% of the output growth. Only 5% is due to productivity growth. However, not all the industries under consideration experienced a positive average annual productivity change over the time span of twenty years. For aluminum, iron and steel and paper industries a declining productivity trend pulled down the positive impact of input growth. High volatility in productivity trends with fluctuations ranging from positive to negative growth rates characterizes the period 1973-93.

To demonstrate this we subdivide the time span of two decades into three sub-periods, 1973-1985, 1985-1991, 1991-1993. The first period can be designated as the pre-liberalization era. Prior to 1985 the public sector was expected to be the main driving force for growth in India. Although the process for opening up sectors reserved for the public sector to the private sector started in the mid-seventies the official process of liberalization started in 1984 and culminated in 1991. Economic reforms towards liberalization (up to 1991) and subsequent globalization in India are being reflected in flexible price policies, enhanced role of big business houses, increased imports, technology transfer, reduction in subsidies etc. (Datt and Sundharam, 1998).

For all sectors except for fertilizer, glass, aggregate manufacturing and total industry, the 1973-85 period is characterized by a negative productivity trend. The following six years show a positive productivity trend followed by negative growth for all the sectors except for iron and steel. Iron and steel illustrates a reverse trend for the last two subperiods with a decline in productivity between 1985 and 1991 and substantial increase in productivity thereafter. Together with mostly positive growth in total inputs, changes in productivity explain the magnitude and behavior of sectoral output.

Econometric Analysis

The results from the econometric model estimation are given in Table 4. The majority of our parameter estimates (88 out of 160 and 98 out 160 are significant at five and ten percent levels of significance respectively) are statistically significant. Conventional goodness of fit is checked through R^2. Except for five R^2 values all are high, ranging between .50 and .99 for input share equations. The technological change equation (15), however, has a very low R^2 value.

The empirical validity of the translog fit to the selected energy intensive manufacturing industries has been checked through positivity of the cost shares at the means of the data as well as at each data point and through the negative semi-definite property of the Hessians and/ or Lau's test (1978). The tests indicate the wellbehavedness of the cost function. All the estimates of average cost shares are statistically significant.

Cost Share Trends

Despite changing temporal patterns, material and energy shares have consistently dominated over labor and capital shares in the aluminum, cement, glass and paper sector (Table 5, Figures 1a-1h). Material cost share dominates over other cost shares in all industries during the whole period under consideration. For cement, the material cost share shows a declining trend since 1979-80. In 1993-94 it was even lower than energy cost share. The energy cost share has exceeded labor and capital cost share for all industries except iron and steel and aggregate manufacturing as well as total industry. For cement the energy share was substantially higher than labor and capital cost share throughout the study period, for glass it was higher immediately following 1974-75, for aluminum after 1975-76, for paper after 1976-77, and for fertilizer eventually from 1983-84 on. The rising energy prices since 1973-74 led to substantial increases in shares of energy cost within most industries.

From the estimated values of a_i it can be concluded that the material price has the largest effect on the aggregate cost/sectoral price followed by energy, labor and capital prices for all the sectors. This is also consistent with the intuition built up from the pattern of relative shares of the inputs shown in Figures 1a-1h.

Cross elasticities (b_{le}) of the share of energy with labor are negative for all the sectors except cement and total industry, i.e., the share of labor decreases with higher energy prices. This is consistent with the changing cost share pattern of labor of Figures 1a-1h. Cross elasticities of the share of energy with materials prices (b_{me}) are negative for all the industries except for iron and steel and fertilizer. Only for these sectors (iron and steel and fertilizer), the share of materials does not decrease with energy prices. The share of capital decreases with increasing energy prices due to negative share elasticities for all industries except cement.

Productivity Trends

For the technical bias (b_{it}) parameter, during the sample period the estimates show energy using bias for all the sectors except iron and steel (Table 6). That is, with constant relative input prices, the value shares of energy will increase over time. Alternatively, the rate of technological change decreases with increases in energy prices. If an increase in technical change or productivity is considered as an indicator for welfare gain our findings show that an energy price increase would affect welfare adversely. The corresponding bias is labor saving for all sectors, and capital saving for aluminum, fertilizer and paper. Material using bias is present in all sectors except aluminum and cement.

The annual rate of technical change decelerated (represented by b_{tt}) for aggregate manufacturing, total industry, iron and steel, and paper and accelerated for aluminum, cement, fertilizer and glass, although at insignificant levels. The insignificance of the acceleration in the technological change parameter estimate (b_{tt}) may be an indication of the statistical invalidity of the assumption of constant acceleration or deceleration of technological change. An enhanced analysis would therefore allow for flexible technological change over time through for example addition of dummy variables for different time periods.

Generally, the low explanatory power of the technological change equation (15) indicates a need for further investigation. Reasons for the low explanatory power need to be checked across other studies. Most studies, however, do not report the estimates for the equation. A reason for the low explanatory power may lie in the partial regulation of output prices in the Indian economy, where changes in input prices may not be clearly reflected in output price changes. This, however, as well as other market imperfections may apply to most other countries as well. Moreover, in Indian industries, technology imports and transfers may have a greater impact than endogenous trends. Additional research on these factors would be useful in determining the best policy design for the Indian environmental development strategy. Despite this, the significant bias parameter estimates do provide useful estimates and are a step forward compared to previous studies in Indian context which are based on Hicks neutral technical change.

Patterns of Input Substitution

We further computed the price elasticities (Table 7) at the means of the data. Positivity of cross price elasticity estimates indicates substitutability among inputs, while negativity indicates complementarity. The price elasticity estimates reveal that a) labor and capital are substitutes for all sectors; b) materials and labor are substitutes for all sectors except aluminum; c) capital and materials as well as energy and materials are substitutes for all sectors except cement; d) labor and energy are substitutional except for fertilizer, glass and iron and steel; e) energy and capital are substitutes for aluminum, cement and paper but complements for fertilizer, glass, iron and steel, aggregate manufacturing and total industry (Table 8).

Negative own price elasticity estimates especially for energy input have far reaching implications as far CO_2 emissions are concerned. Although positive b_{ee} parameters in Table 4 indicate that with rising energy price the cost share would increase, the price elasticities E_{ee} (Table 7) indicate that in physical terms industries do reduce their energy consumption. This would reduce carbon emissions proportional to the quantity reduction in energy use. For aggregate manufacturing with one percent increase in energy price the cost share of energy input would go up by .0523 (Table 4) but in physical units energy use would decline by .2% as derived from the price elasticity. Energy price elasticities range from very low –0.02 for total industry to as high as –0.57 for the cement sector. Few of the cross and own price elasticities in our analysis are greater than or close to unity. These show a relatively responsive structure. Other inputs are only weakly substitutable or complementary.

The price elasticities also inform about the behavior of average productivity of the various factors. For example, the own price elasticity of -.24 for energy in the paper industry implies that a 1% increase in the price of energy would increase energy productivity by .24%. Now given that energy and capital are substitutable to each other an increase in the price of energy would on the one hand improve energy productivity (reduce energy intensity) because of the negative own price elasticity but would on the other hand additionally reduce capital productivity and hence increase capital intensity.

No general conclusion regarding productivity responses can be drawn, however, since the relationships between the input factors are not uniform across industries and vary between complementarity and substitutability (Table 8). An increase in energy prices would have varying impacts across industries so far as average factor productivity is concerned. However, low or moderate values for price elasticity estimates in Table 7 indicate a relatively limited degree of flexibility within the industries to adjust to rising energy prices within the short run. Coupled with the findings of energy using bias and insignificant or decelerating technological change, this suggests that price-based policies to abate carbon in the Indian economy may have limited impact, and may result in substantial economic costs in the longer run.

COMPARATIVE RESULTS

While, as we have noted, materials and energy had the dominant shares for the Indian economy during the sample period, for the U.S. economy labor share was the highest during the postwar era (Jorgenson et al., 1987). In the Canadian economy as well labor share is higher than capital share, but it is the materials share that dominated over all the inputs. As regards sources of growth in output, input growth dominated over productivity growth in both the US and Canadian economies.

Table 9 gives an overview of the results on price elasticity of demand for energy and input biases in technical change from various studies. Own price elasticity estimates for long run and short run are available for a limited number of countries compared to the intermediate run estimates obtained from the static model. The range of variation for short run estimates is –.25 to –.49. The long run estimates vary from a low of –.4 to –.84. The static model results are available for both developed and developing nations. Elasticity estimates vary across countries, industry coverage and period of study. However, one feature is common: the values are all less than one, reflecting either inelasticity or moderate elasticity. Moreover, it cannot be determined from above findings if developing countries have lower or higher price elasticity values compared to developed countries. Generally it can be expected that data from developing economies with more regulation and control may produce underestimates. For total industry, the values are all in the inelastic range, the lowest being the Indian estimate. For specific industries aggregate responses are higher. For iron and steel the Canadian estimate (–.57) is higher than estimates for India (-.03 and –.39). For pulp and paper, the estimates vary between –.24 and –.60 while for iron and steel the limits are further apart, –.01 and -.57. The estimates from the current study show mostly inelastic values except for cement, with –.57 showing relatively moderate elasticity.

Bias parameters across nations and studies (Table 9) reveal some common features. Capital saving bias is observed for all industries and countries except the Canadian iron and steel sector. All statistically significant estimates show energy using bias and labor saving and material using bias. The only exceptions are primary metals in the US, where Jorgenson et al. (1987) observed labor using and materials saving biases, and stone and glass where they report labor using bias, as well as iron and steel, where we find energy savings bias and cement where a bias towards materials saving is present. The labor saving parameter shows a yearly savings in the share of labor between .0025 and .0058. The labor saving values are comparable for India, the US and Canada. This may be due to the fact that the bias is implicitly imported to India with technology transfer from the latter two and other industrialized countries. Labor cost shares are higher for more industrialized countries which is consistent with labor savings bias.

The extent of capital, material and energy using or saving biases are country and industry specific. For the Indian aluminum sector, the energy using bias is higher compared to other sectors. The estimates show that for India the non price induced increase in energy cost share varies in the range of .0007 and .0063 per year. That means, for example for aggregate manufacturing, it would take about 100 years to double the 1993-94 cost share of energy (7.2%) if the estimated bias remains constant over the years. Given the dual interpretation of the bias parameters it can be said that with keeping all other prices constant a doubling of the energy price in India would lead to a decline in total productivity growth for the industry sector of .07%. Given the insignificant estimate for Canada it can be said that productivity for the aggregate manufacturing would hardly be affected. Yet, the industry level estimates for Canada do not lead to a very encouraging picture as well. For iron and steel, for example, the effect of a doubling of the energy price would lead to a decline in the industry's productivity by .038%. The same figure for India would be almost .17%. It appears that the adverse effect on productivity growth in India is higher compared to the US and Canada for comparable sectors.

Regarding the rate of change of technical progress over time, the observed deceleration of technological change in the Indian pulp and paper industry has its parallel in the US paper sector for the period 1958-74 (Jorgenson, Gollop and Fraumeni, 1987). As opposed to our deceleration in technical change in iron and steel industry over 1973-93 accelerating technological change in iron and steel was observed by Jorgenson et al. (1987) for the US primary metals industry during 1958-74. Reverse are the findings for the glass industry. The US glass industry shows decelerating technological change while the Indian industry shows an acceleration. For the US economy as a whole, technological change has been negatively correlated with energy prices and positively correlated with materials prices (Hogan and Jorgenson, 1991). This pattern implies that energy price increases would have a negative, long-run effect on productivity. The patterns found in the present study reveal a similar possibility for the Indian energy intensive and total industries but at varying degree. These variations support the need for country specific studies especially when implications are to be derived for long run time horizons.

CONCLUDING REMARKS

Our findings on own-price responses within the Indian energy intensive manufacturing sectors indicate that price-based policies would be effective in reducing energy use, and thus lowering carbon output, in Indian industry. Simultaneously, however, our results on technological change and patterns of factor price bias suggest that such policies could have a negative long run effect on productivity in these sectors, thus leading to welfare loss. Moreover, inter-input substitution possibilities are relatively weak, so that such policies might also have deleterious short and medium-run effects on sectoral growth. Differing details among the sectors, however, indicate a need for further research to link disaggregate and aggregate findings on energy demand and output growth in India, and for investigation of additional Indian economic sectors to estimate technological and productivity trends for the Indian economy as a whole.

It should be noted that the methodology adopted here is an advance over earlier studies on Indian industries to the extent that it relaxes the assumption of Hicks neutrality in allowing for technical bias parameters. Thus, the reported results can be considered as a first round of results for the Indian economy using a comparable methodology with other countries. The challenge for future studies remains to derive results from a model based on a minimum of maintained hypotheses, in particular relaxing the assumptions of constant returns to scale and perfect competition.

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Table 1: Ownership Patterns of Indian Energy Intensive Industries

	Private	Public
Aluminum	34% of total installed capacity	66% of total installed capacity
Cement	85% of total installed capacity	25% of total installed capacity
Fertilizer[a]	35% of total installed capacity	49% of total installed capacity
Iron and Steel	37% of total crude steel production	63% of total crude steel production
Paper	95% of ownership	5% of ownership

[a] The difference of 16% is held in the cooperative sector.

Table 2: Price and Distribution Control

	Policy
Aluminum	• Highly regulated until the late eighties • Decontrol in early 1989
Cement	• Price and distribution control until 1982 • Partial decontrol introduced in 1982 (levy obligation of 66.6% subject to a retention price) • In early 1989 withdrawal of all price and distribution controls
Fertilizer	• Distribution control and retention price system until 1991 • Dual pricing policy introduced in 1991 • Gradual removal of price and distribution control since mid 1992
Iron and Steel	• Dual price system from 1972 on • Since 1992 price and distribution completely decontrolled for private sector units • Distribution to priority sectors still controlled for other units
Paper	• Multiple controls including price control over most of the past • Removal of price and distribution control for several kinds of paper since 1988

Source: Datt and Sundharam, 1998.

Table 3: Sources of Growth in Sectoral Output (1973-1993)

Sector/ Year	Rate of Output Growth	Labor Input	Capital Input	Material Input	Energy Input	Total Input	Rate of Productivity Growth
Aluminum							
1973-1993	5.10%	0.17%	0.83%	2.54%	1.72%	5.26%	-0.16%
1973-1985	4.23%	0.20%	0.08%	2.50%	2.60%	5.36%	-1.14%
1985-1991	10.69%	0.27%	1.98%	3.61%	2.43%	8.29%	2.40%
1991-1993	-6.42%	-0.32%	1.91%	-0.37%	-5.66%	-4.44%	-1.97%
Cement							
1973-1993	8.69%	0.23%	2.89%	2.57%	2.22%	7.92%	0.77%
1973-1985	8.47%	0.31%	3.61%	3.60%	2.01%	9.53%	-1.06%
1985-1991	11.88%	0.07%	1.63%	1.25%	3.28%	6.24%	5.64%
1991-1993	0.43%	0.22%	2.34%	0.37%	0.33%	3.27%	-2.84%
Fertilizer							
1973-1993	10.10%	0.18%	1.45%	5.07%	1.10%	7.80%	2.31%
1973-1985	11.02%	0.24%	1.37%	5.55%	1.17%	8.32%	2.69%
1985-1991	15.19%	0.04%	1.57%	6.86%	1.59%	10.06%	5.13%
1991-1993	-10.62%	0.21%	1.59%	-3.18%	-0.80%	-2.18%	-8.44%
Glass							
1973-1993	6.38%	0.06%	2.35%	1.99%	1.11%	5.50%	0.88%
1973-1985	5.31%	0.08%	0.57%	1.09%	1.20%	2.94%	2.37%
1985-1991	11.98%	0.25%	4.01%	5.30%	2.26%	11.81%	0.16%
1991-1993	-3.97%	-0.67%	8.03%	-2.56%	-2.90%	1.90%	-5.87%
Iron and Steel							
1973-1993	7.58%	0.23%	2.60%	4.81%	0.77%	8.41%	-0.84%
1973-1985	7.79%	0.34%	2.68%	5.27%	0.97%	9.25%	-1.46%
1985-1991	6.25%	-0.03%	2.29%	4.35%	0.46%	7.07%	-0.82%
1991-1993	10.25%	0.38%	3.03%	3.46%	0.55%	7.41%	2.83%
Paper							
1973-1993	5.25%	0.26%	1.88%	2.88%	1.01%	6.03%	-0.78%
1973-1985	5.23%	0.30%	2.00%	3.05%	1.05%	6.41%	-1.18%
1985-1991	7.03%	0.18%	1.17%	3.41%	1.46%	6.22%	0.81%
1991-1993	0.01%	0.24%	3.32%	0.28%	-0.62%	3.22%	-3.20%
Agg. Manufacturing							
1973-1993	7.35%	0.20%	1.77%	4.60%	0.43%	7.00%	0.36%
1973-1985	7.59%	0.22%	1.63%	4.26%	0.47%	6.57%	1.02%
1985-1991	6.91%	0.14%	1.55%	4.81%	0.40%	6.91%	0.00%
1991-1993	7.27%	0.21%	3.32%	6.05%	0.23%	9.82%	-2.55%
Total Industry							
1973-1993	7.65%	0.21%	1.69%	4.55%	0.53%	6.97%	0.68%
1973-1985	7.80%	0.25%	1.61%	4.11%	0.60%	6.57%	1.23%
1985-1991	7.01%	0.13%	1.38%	4.76%	0.49%	6.76%	0.25%
1991-1993	8.70%	0.22%	3.07%	6.48%	0.25%	10.02%	-1.32%

Table 4: Parameter Estimates

	Aluminum		Cement		Fertilizer		Glass	
Parameter	Estimate	t-statistic	Estimate	t-statistic	Estimate	t-statistic	Estimate	t-statistic
b_{mm}	0.1353	3.7250	0.4775	4.4714	0.0155	0.1027	-0.0174	-0.1560
b_{ml}	-0.0771	-7.7697	-0.0366	-1.4195	-0.0251	-0.9213	0.0489	1.7438
b_{me}	-0.0575	-1.6343	-0.1807	-3.6717	0.0092	0.0975	-0.0582	-0.9307
a_m	0.5308	39.3013	0.5126	29.7448	0.5598	13.5989	0.4419	24.3541
b_{mt}	-0.0012	-1.2444	-0.0043	-2.9299	0.0041	0.9895	0.0004	0.3296
b_{ll}	0.0734	9.1686	-0.0257	-1.9177	0.0308	3.3798	-0.0255	-1.9257
b_{le}	-0.0063	-0.5928	0.0181	1.3527	-0.0205	-1.1348	-0.0630	-3.2995
a_l	0.0891	21.4008	0.1327	29.4380	0.0771	9.7575	0.1981	31.8779
b_{lt}	-0.0026	-10.1582	-0.0040	-9.7322	-0.0025	-3.0518	-0.0033	-6.4051
b_{ee}	0.0908	1.6861	0.0395	1.3932	0.1088	1.5766	0.1849	3.3800
a_e	0.2042	8.9185	0.2296	23.7077	0.1246	4.4989	0.2807	17.6980
b_{et}	0.0063	3.9862	0.0054	7.2646	0.0040	1.4921	0.0020	1.8443
a_t	0.0346	0.9545	0.0098	0.3106	-0.0209	-0.4817	-0.0043	-0.1556
b_{tt}	-0.0031	-1.0280	-0.0015	-0.5519	-0.0005	-0.1352	-0.0008	-0.3531
a_k	0.1759	8.0863	0.1251	8.1963	0.2384	13.0072	0.0793	5.8466
b_{kk}	0.0176	0.4332	0.0928	1.2977	0.0824	1.6086	-0.0025	-0.0282
b_{mk}	-0.0006	-0.0268	-0.2602	-3.5278	0.0004	0.0058	0.0267	0.3098
b_{lk}	0.0101	1.5332	0.0442	2.4792	0.0147	1.0668	0.0396	1.4220
b_{ek}	-0.0270	-0.6985	0.1231	3.7845	-0.0975	-2.3073	-0.0637	-1.4021
b_{kt}	-0.0024	-1.5364	0.0028	2.5213	-0.0056	-2.9732	0.0009	0.8737
R^2_m	0.13		0.89		0.50		0.42	
R^2_l	0.94		0.96		0.85		0.95	
R^2_e	0.65		0.95		0.71		0.69	
R^2_t	0.05		0.01		0.001		0.01	

m = Material e = Energy
l = Labor k = Capital

Table 4: Parameter Estimates (contd.)

	Iron and Steel		Paper		Agg. Manufacturing		Total Industry	
Parameter	Estimate	t-statistic	Estimate	t-statistic	Estimate	t-statistic	Estimate	t-statistic
b_{mm}	-0.0515	-0.9611	0.0020	0.0331	0.0394	1.2947	0.0310	0.9092
b_{ml}	-0.0454	-4.5059	-0.0548	-2.5444	-0.0111	-0.9908	-0.0133	-1.2925
b_{me}	0.0279	1.1077	-0.0789	-3.1903	-0.0243	-1.7003	-0.0403	-2.4429
a_m	0.5414	39.0277	0.5482	55.8441	0.7275	163.4470	0.6759	126.4840
b_{mt}	0.0064	6.6165	0.0018	2.4276	0.0016	2.7400	0.0018	2.8276
b_{ll}	0.0786	11.9847	0.0634	3.0352	0.0109	1.6994	0.0177	2.9952
b_{le}	-0.0340	-5.7982	-0.0006	-0.0681	-0.0051	-0.9869	0.0021	0.3845
a_l	0.1539	53.1319	0.1523	34.4692	0.1358	75.3284	0.1449	76.9192
b_{lt}	-0.0058	-28.2610	-0.0043	-12.4020	-0.0032	-13.0446	-0.0035	-14.4541
b_{ee}	0.0658	3.3587	0.0963	7.5763	0.0523	5.8933	0.0762	7.2859
a_e	0.1706	17.2100	0.1462	38.7861	0.0689	28.6159	0.0839	27.4461
b_{et}	-0.0017	-2.6349	0.0030	11.1938	0.0007	2.7542	0.0006	1.8160
a_t	-0.0107	-0.2630	0.0054	0.2232	-0.0323	-1.9403	-0.0340	-2.1825
b_{tt}	0.0018	0.5262	0.0003	0.1535	0.0028	2.0216	0.0027	2.0962
a_k	0.1341	12.0592	0.1533	13.4763	0.0677	33.2215	0.0953	35.8703
b_{kk}	-0.0100	-0.2881	-0.1068	-2.1330	0.0217	2.1584	0.0218	2.0130
b_{mk}	0.0689	1.7971	0.1317	2.7672	-0.0040	-0.3198	0.0226	1.4810
b_{lk}	0.0008	0.0883	-0.0080	-0.4496	0.0053	0.7900	-0.0064	-0.9784
b_{ek}	-0.0597	-3.1377	-0.0168	-0.9795	-0.0230	-3.8300	-0.0380	-5.0499
b_{kt}	0.0010	1.3422	-0.0005	-0.5764	0.0009	3.5312	0.0011	3.7275
R^2_m	0.80		0.67		0.36		0.39	
R^2_l	0.99		0.94		0.97		0.98	
R^2_e	0.49		0.96		0.91		0.92	
R^2_t	0.01		0.02		0.16		0.17	

m = Material e = Energy
l = Labor k = Capital

Table 5: Cost Share - average for the years 1973-1993 (in percentage)

Inputs	Aluminum	Cement	Fertilizer	Glass	Iron & Steel	Paper	Agg. Manuf.	Total. Industry
Capital	15.6	15.7	19.0	10.6	15.7	14.3	8.2	11.0
Labor	7.0	8.8	5.8	16.4	10.4	10.8	10.5	11.0
Energy	25.6	30.1	15.2	26.6	13.7	16.0	7.2	8.5
Materials	51.8	45.5	60.0	46.3	60.3	58.9	74.2	69.6

Table 6: Technical Change Biases

Inputs	Aluminum	Cement	Fertilizer	Glass	Iron & Steel	Paper	Agg. Manuf.	Total Industry
Materials	saving	saving	using	using	using	using	using	using
Labor	saving	saving	saving	saving	saving	saving	saving	saving
Energy	using	using	using	using	saving	using	using	using
Capital	saving	using	saving	using	using	saving	using	using

Table 7: Price Elasticities

	Aluminum	Cement	Fertilizer	Glass	Iron & Steel	Paper	Agg. Manuf.	Total Industry
E_{mm}	-0.2207	0.5046	-0.3739	-0.5744	-0.4823	-0.4072	-0.2050	-0.2599
E_{ml}	-0.0788	0.0071	0.0163	0.2698	0.0284	0.0148	0.0896	0.0908
E_{me}	0.1448	-0.0967	0.1673	0.1409	0.1828	0.0260	0.0389	0.0270
E_{mk}	0.1547	-0.4149	0.1903	0.1637	0.2711	0.3664	0.0764	0.1421
E_{lm}	-0.5831	0.0369	0.1688	0.7608	0.1653	0.0810	0.6356	0.5743
E_{ll}	0.1179	-1.2055	-0.4108	-0.9910	-0.1382	-0.3037	-0.7912	-0.7293
E_{le}	0.1652	0.5066	-0.2009	-0.1168	-0.1912	0.1544	0.0230	0.1040
E_{lk}	0.3000	0.6620	0.4429	0.3470	0.1641	0.0683	0.1326	0.0510
E_{em}	0.2935	-0.1464	0.6605	0.2449	0.8075	0.0957	0.4031	0.2212
E_{el}	0.0453	0.1477	-0.0767	-0.0720	-0.1452	0.1040	0.0336	0.1346
E_{ee}	-0.3891	-0.5681	-0.1322	-0.0398	-0.3818	-0.2378	-0.1979	-0.0179
E_{ek}	0.0504	0.5668	-0.4517	-0.1331	-0.2805	0.0380	-0.2388	-0.3379
E_{km}	0.5141	-1.2019	0.6025	0.7151	1.0430	1.5097	0.6930	0.9016
E_{kl}	0.1347	0.3694	0.1356	0.5372	0.1086	0.0514	0.1696	0.0511
E_{ke}	0.0826	1.0847	-0.3622	-0.3344	-0.2443	0.0424	-0.2092	-0.2616
E_{kk}	-0.7314	-0.2522	-0.3759	-0.9179	-0.9072	-1.6036	-0.6534	-0.6911

Table 8: Interfactor Relationship

	Aluminum	Cement	Fertilizer	Glass	Iron & Steel	Paper	Agg. Manuf. /Total Industry
Capital-Labor	S	S	S	S	S	S	S
Capital-Energy	S	S	C	C	C	S	C
Capital-Material	S	C	S	S	S	S	S
Labor-Energy	S	S	C	C	C	S	S
Labor-Material	C	S	S	S	S	S	S
Energy-Material	S	C	S	S	S	S	S

S = Substitutes C = Complements

Table 9: Comparative Results

Coverage	Country	Own – price elasticity for energy			Constant Acceleration of Productivity Growth	Bias in technical change for inputs				Reference
		Short run	Long run	Static		Capital	Material	Labor	Energy	
Industry	US		-.4							Edmonds et al., 1985[e]
Industry	Cross country[b] (1959-73)		-.84							Pindyck, 1979
Industry	India (1960-71)			-.65						Vashisht, 1984[c]
Industry	Pakistan (1960-70)			-.82						Iqbal, 1986[c]
Industry	India (1973-93)			-.02	-.0027	.0011	.0018	-.0035	.0006[a]	**Authors**
Agg. Manufacturing	Canada (1957-76)	-.25	-.64	-.27		-.0012	.0048	-.0037	.2[a]	Berndt et al., 1981
Agg. Manufacturing	India (1973-93)			-.20	-.0028	.0009	.0016	-.0032	.0007	**Authors**
Primary Metal	US (1958-74)				.0123[a]	-.0016	-.0027	.0044	-.00007[a]	Jorgenson et al., 1987
Basic Metal	Pakistan (1960-70)			-.01						Iqbal, 1986[c]
Iron and Steel	Canada (1957-76)	-.49	-.55	-.57		.0008	.0045	-.0056	.00038	Berndt et al., 1981
Iron and Steel	India (1965-66 to 1973-74)			-.03						Shankar, 1983
Iron and Steel	India (1973-93)			-.39	-.0018[a]	.001[a]	.0064	-.0058	-.0017	**Authors**
Paper and Allied	US (1958-74)				-.0083	-.001	-.0013[a]	.0015[a]	.00077	Jorgenson et al., 1987
Paper	Pakistan (1960-70)			-.37						Iqbal, 1986[c]
Paper	India (cross section of firms)			-.60						Ramaswamy et al., 1998
Pulp and Paper	Indonesia (firm level data)			-.49						Pitt, 1985[c]
Pulp, Paper and Paper Board	India (1973-93)			-.24	-.0003[a]	-.0005[a]	.0018	-.0043	.003	**Authors**
Cement	India (1965-66 to 1973-74)			.06			.0025			Shankar, 1983
Cement	India (1973-93)			-.57	.0015[a]	.0028	-.0043	-.004	.0054	**Authors**
Aluminum	India (1973-93)			-.39	.0031[a]	-.0024[a]	.-0012[a]	-.0026	.0063	**Authors**
Fertilizer	India (1973-93)			-.13	.0005[a]	-.0056	.0041[a]	-.0025	.004[a]	**Authors**
Stone, Glass	US (1958-79)				-.0016[a]	-.0022	.0025[d]	.0004		Jorgenson et al., 1987
Glass	India (1973-93)			-.04	.0008[a]	.0009[a]	.0004[a]	-.0033	.002	**Authors**

[a] insignificant
[b] estimates are reported for Canada, France, Italy, Japan, The Netherlands, Norway, Sweden, UK, USA, West Germany. The range of the estimates is -.83 to -.87.
[c] quoted from Dahl (1991); [d] for intermediate input; [e] average from several studies

Figure 1a: Input Cost Shares – Aluminum

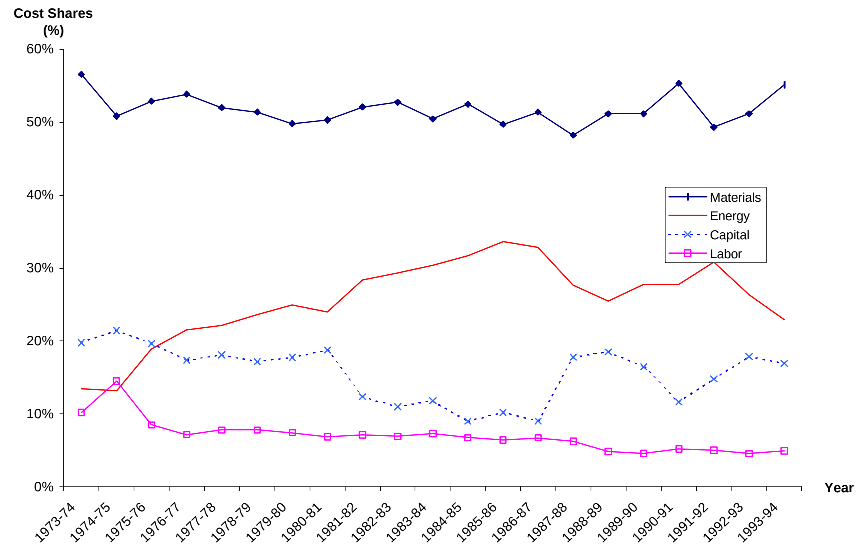

Figure 1b: Input Cost Shares – Cement

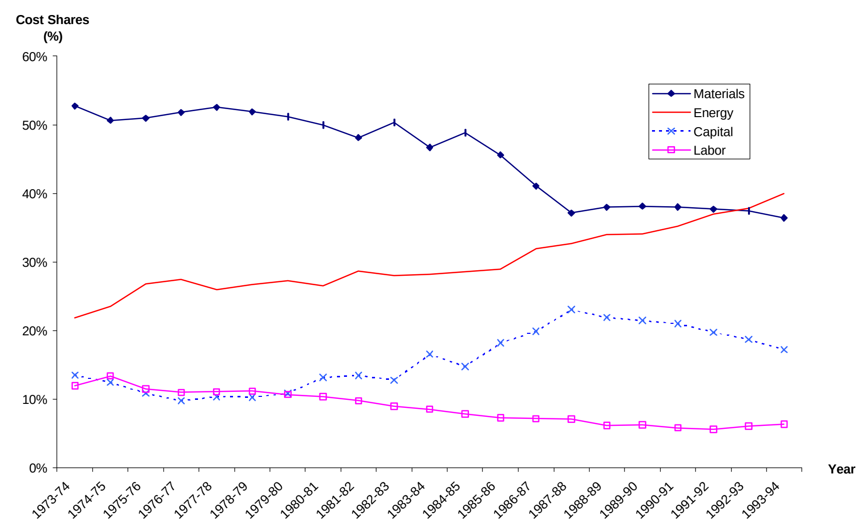

Figure 1c: Input Cost Shares – Fertilizer

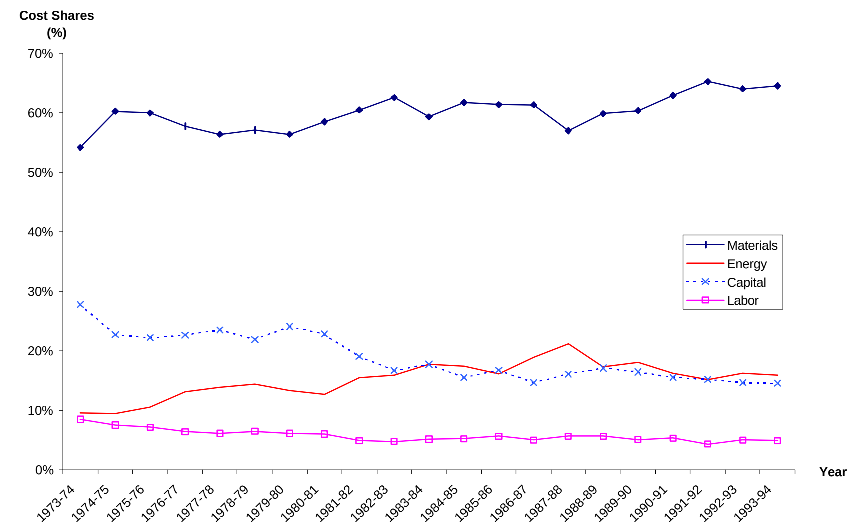

Figure 1d: Input Cost Shares – Glass

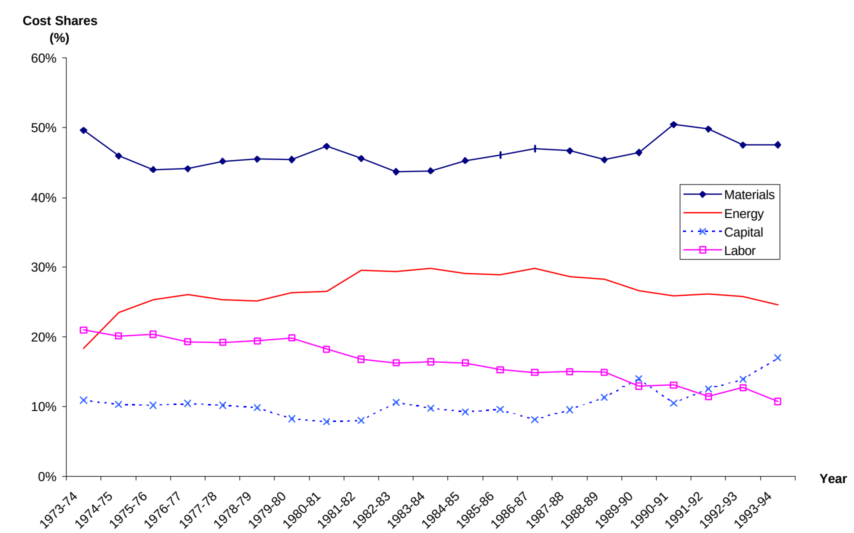

Figure 1e: Input Cost Shares – Iron and Steel

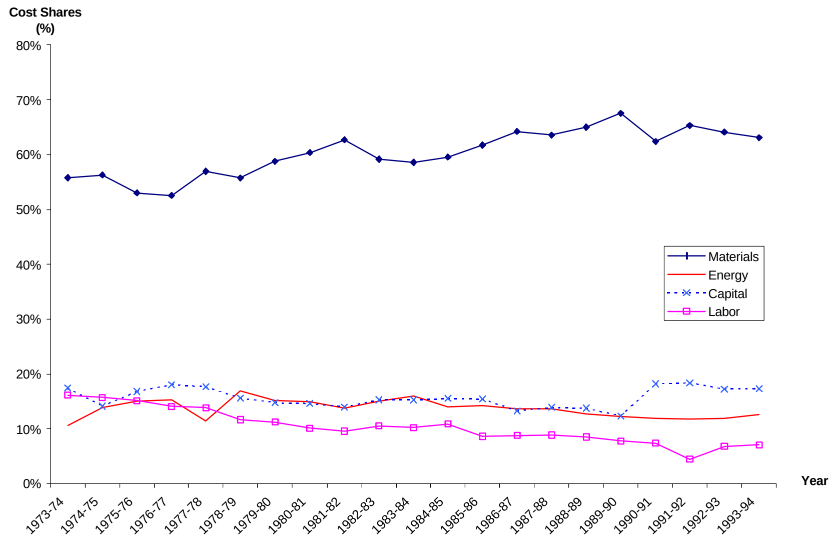

Figure 1f: Input Cost Shares – Paper

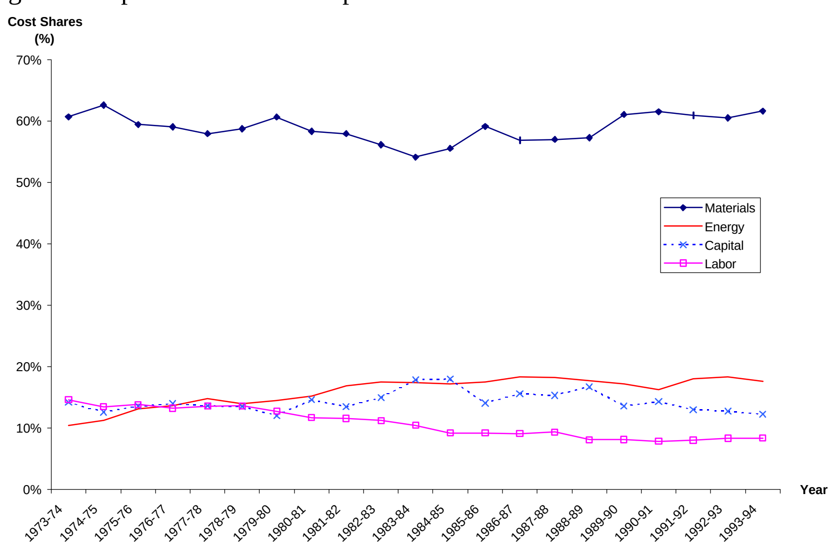

Figure 1g: Input Cost Shares – Aggregate Manufacturing

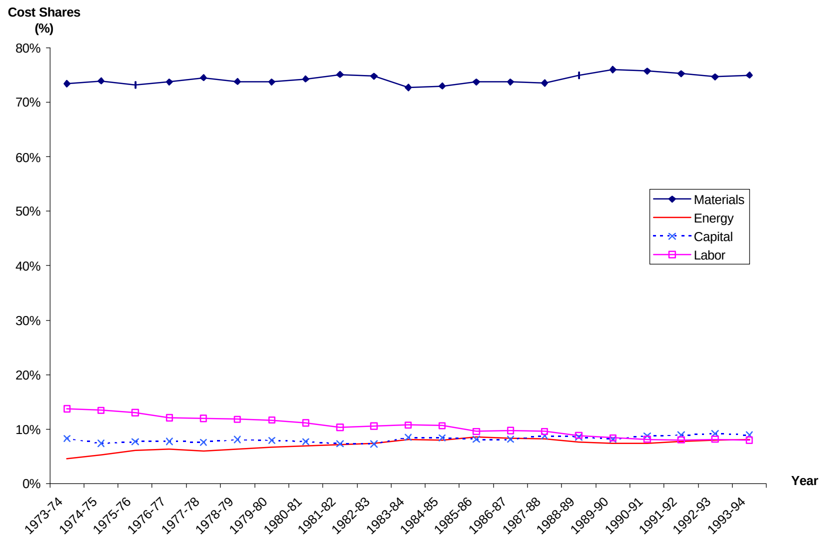

Figure 1h: Input Cost Shares – Total Industry